REMARKS

The present invention is a method for constructing a reservoir model representative of an underground reservoir, including discretizing the reservoir by a set of grid cells, and associating with the reservoir model a permeability field constrained by *a priori* geologic data and production data or pressure data obtained from well tests collected in the reservoir. The method constructs an initial reservoir model including generating a permeability field in accordance with a stochastic model coherent with the *a priori* geologic data; identifies zones inside the underground reservoir; calculates permeabilities of the zones, using a simulator to simulate fluid flows for estimating simulated production data or simulated pressure data, and estimates corrections of the permeabilities for reducing a difference between the production data or pressure data obtained from well tests and the simulated production or simulated pressure data; propagates the corrections to the set of grid cells to the reservoir model by an iterative optimization process comprising minimizing a function which depends on the corrections, using a technique of gradual deformation of utilizations of the stochastic model; and uses the reservoir model, including the corrections propagated to the set of grid cells, to develop the underground reservoir.

Claims 27-28, 35 and 36 stand rejected by 35 U.S.C. §103 as being unpatentable over United States Patent 6,064,944 (Sarda et al) in view of U.S. Published Application US 2006/0020438 (Huh et al). The Examiner reasons in part as follows:

> Sarda discloses: 27. (Currently Amended) A method for constructing a reservoir model representative of an underground reservoir, including discretizing said underground reservoir by a set of grid cells, and associating with said reservoir model a permeability field

constrained by a priori geologic data and production data or pressure data obtained from well tests collected in said underground reservoir comprising **(Fig 1 and description; col: 8 line: 55-57):**

a) constructing an initial reservoir model including generating a permeability field in accordance with a stochastic model coherent with the a priori geologic data **(Abstract: "physically exploring the original reservoir based on the determined physical property"; col: 3 line: 12-15);**

Sarda however does not fully disclose the following limitations, which are disclosed by Huh's analogous simulation system.

b) identifying zones inside said underground reservoir **(Fig 2; para 41)**;

c) calculating permeabilities of said zones **(para 41)**,

using a simulator to simulate fluid flows for estimating simulated production data or simulated pressure data **(Fig 5A and description)**, and

estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data **(para 104: "permeability-saturation relationship and dispersion level) were set to match the experimentally determined values")**;

d) propagating said corrections to said set of grid cells of said reservoir model by an iterative optimization process comprising minimizing a function which depends on said corrections, using a technique of gradual deformation of realizations of said stochastic model **(para 0009)**; and

e) using said reservoir model, including said corrections propagated to said set of grid cells, to develop said underground reservoir **(col: 1 line: 11-13)**.

It would have been obvious to one of ordinary skill in the art "oil reservoir modeling" at the time of Applicant's invention to combine the references in order to have a finer granularity for the grids / zones. Thus, allowing, for a better and more accurate simulation, which in turn saves time and money associated with developing a reservoir based on incorrect or inadequate simulation outputs.

These grounds of rejection are traversed for the following reasons.

It is submitted that neither Sarda nor Huh discloses associating with said reservoir model a permeability field constrained by *a priori* geologic data and production data or pressure obtained from well tests in association with steps c) and d) of claim 27 when claim 27 is properly construed. Specifically Claim 27 recites a method for constructing reservoir model...and associating with said reservoir model a permeability field constrained by a prior geologic data and production data or pressure data obtained from well tests collected in said underground reservoir...c) calculating permeabilities of said zones, using a simulator to simulate fluid flows for estimating simulated production data or simulated pressure data and estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data; d) propagating said corrections to said set of grid cells of said reservoir model by an iterative optimization process comprising minimizing a function which depends on said corrections, using a technique of gradual deformation of realizations of said stochastic model; and e) using said reservoir model, including said corrections propagated to said set of grid cells to develop said underground reservoirs.

The Examiner asserts Huh discloses calculating permeabilities of said zone in paragraph [0041] and using a simulator to simulate fluid flows for estimating simulated production data or simulated pressure data in Fig. 5A and the description thereof in the Huh specification. However, the Examiner's reliance on paragraph [0041], Fig. 5A and the description thereof is misplaced. In the first place, paragraph [0041] states as follows:

> Through advanced reservoir characterization techniques, the reservoir area **5** can be represented by gridcells on a scale from

> centimeters to several meters, sometimes called a fine-scale grid. Each gridcell can be populated with a reservoir property, including for example rock type, porosity, permeability, initial interstitial fluid saturation, and relative permeability and capillary pressure functions.

This description is merely a reference to discretization.

Moreover, Fig. 5A is described in paragraph [0031] of Hugh as "Fig. 5A illustrates the effective coordination number, z, on total oil recovery for a multiple-contact miscible flood simulated using the method of this invention" and further paragraph [0086] of Huh describes a "example 1" which includes the statement describing Fig. 5A as follows:

> "Fig. 5A shows that increasing z results in reduced oil recovery and Fig. 5B shows that increasing z results in earlier solvent breakthrough. Both the oil recovery and solvent breakthrough curves are sensitive to the value of z. In particular, varying z between two and five reduces oil recovery at 1.5 pore volumes produced from 94% to 52% and reduces the point at which the produced fluid reaches a concentration of 50% solvent from 0.55 to 0.24 pore volumes produced. The MCM phase behavior description in Table 1 was used in this example and the Damköhler numbers were assumed to be Da_1=0, Da_2=0.1, and Da_2-0.1. The simulation of this example started at a waterflood residual oil saturation of 0.35 and used 25 gridcells in the one-dimensional model."

It is submitted that nowhere in the above description is there any disclosure of calculating permeabilities of said zones using a simulator to simulate fluid flows for estimating <u>simulated production data or simulated pressure data</u>. If the Examiner persists in this interpretation, it is requested that he fully explain on the record where the foregoing portions of Huh substantially or explicitly disclose this subject matter.

Additionally, the Examiner concludes that Huh in paragraph [0104] discloses "estimating corrections of said permeabilities for reducing a difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data". In the first place, Huh does not disclose anything pertaining to the preamble's recitation of a "associating with said

reservoir model a permeability field constrained by a priori geological data and production data or pressure data obtained from well tests collected in said underground reservoir." The Examiner relies upon paragraph [0104] of Huh. This reliance is misplaced. Paragraph [0104] discloses:

> To evaluate the ability of the method of this invention to simulate the experimental coreflood data, the method of this invention was first applied to the FCM CO_2/Soltrol system. The parameters z, $Da_{solvent}$, $Da_{Mheavy,light}$=0.5. Using the same parameters and assuming C_7=10, a simulation was carried out using the method of this invention for the CO_2/Wasson crude system. All simulation parameters (phase behavior, relative permeability-saturation relationship and dispersion level) were set to match the experimentally determined values (data obtained from Gardner et al.). The viscosity of the oil in the simulation was changed to mimic the Wasson crude and an oil/solvent viscosity ratio of 21. These results are plotted in FIG. 10.

It is submitted that a person of ordinary skill in the art would not find paragraph [0104] above of Huh to disclose estimating corrections of said permeabilities for reducing the difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data". The Examiner does not explain how the "[a]ll simulation parameterizes (phrase behavior relative to permeability-saturation relationship and dispersion level) "language meets the estimating step which includes reducing a difference involving well tests and simulated data. If the Examiner persists in this interpretation, it is requested that he describe in detail the basis thereof.

Huh pertain to a method for simulating a multi-component hydrocarbon-bearing formation to which displacement fluid having at least one component is injected to displace the formation hydrocarbons. Nothing is disclosed in Huh pertaining to the foregoing *a priori* geologic data and production data or pressure

data obtained from well tests collected in said underground zones including the claimed estimating.

Moreover, the Examiner alludes to Fig. 1 of Sarda and column 8, lines 55-57, as teaching "and associating with said reservoir model a permeability field constrained by *a priori* geologic data and production data or pressure data obtained from well tests collected in said underground reservoir," Fig. 1 illustrates a known procedure for determining a regularly fractured medium equivalent to a real fractured medium which is described in column 2, lines 10, *et. seq.* However, what is disclosed therein is a procedure for determining the dimensions a, b, of each block of a section crossed by a regular grid of fractures. Moreover, column 8, lines 55-57, state "this function can, for example, give the transmissivity values between the grids and reservoir whose centers are the pixels of the image". It is submitted that this disclosure does not describe the aforementioned "associating with said reservoir model a permeability field constrained by *a priori* geologic data and production data or pressure data obtained from well tests collected in said underground reservoir". Accordingly, neither Huh nor Sarda disclose the foregoing subject matter which the Examiner concludes is disclosed in Fig. 1 and column 8, lines 55-57 of Sarda.

Step d) recites "propagating said corrections to said set of grid cells of the reservoir model by iterative optimization process comprising minimizing a function which depends on said corrections, using a technique of gradual deformation of realizations of said stochastic model." The Examiner relies upon paragraph [0009] of Huh. However, Huh in paragraph [0009] merely discloses:

> <u>The principle of numerical simulation is to numerically solve equations describing a physical phenomenon by a computer</u>. Such equations are generally ordinary differential equations and partial differential equations. These equations are typically solved using

> numerical methods such as the finite element method, the finite difference method, the finite volume method, and the like. In each of these methods, the physical system to be modeled is divided into smaller gridcells or blocks (a set of which is called a grid or mesh), and the state variables continuously changing in each gridcell are represented by sets of values for each gridcell, In the finite difference method, an original differential equation is replaced by a set of algebraic equations to express the fundamental principles of conservation of mass, energy, and/or momentum within each gridcell and transfer of mass, energy, and/or momentum transfer between gridcells. These equations can number in the millions. Such replacement of continuously changing values by a finite number of values for each gridcell is called "discretization". In order to analyze a phenomenon changing in time, it is necessary to calculate physical quantities of discrete intervals of time called timesteps, irrespective of the continuously changing conditions as a function of time. Time-dependent modeling of the transport processes proceeds in a sequence of timesteps (emphasis added).

The Examiner has provided no explanation of how paragraph [0009], which describes numerical simulation to numerically solve equations describing the physical phenomena, suggests the foregoing propagating of corrections to said set of grid cells of said reservoir model by an iterative optimization process comprising minimizing a <u>function which depends on said corrections, using a technique of gradual deformation of realizations of said stochastic model</u>. In the first place, where is there any disclosure in Huh of "minimization of any function which depends on said corrections" which is the result of the estimating step of the last part of paragraph c) of claim 27? It is submitted that a person of ordinary skill in the art would not consider the disclosure of paragraph [0009] to disclose this subject matter. If the Examiner persists in the stated ground of rejection, it is requested that he specifically point out the rationale for such a conclusion in a much greater degree of particularity other than just referencing paragraph [0009] of how step d) is met.

Huh does not specifically or implicitly disclose simulation of pressure data obtained from well tests. Even if *arguendo* it were to be assumed that the simulation

described in paragraph [0104] of Huh requires a simulation of pressure, the subject matter of the claims would not be met since the simulator of paragraph c) is used to simulate fluid flows "estimating simulated production data or simulated pressure data" which are used for "estimating corrections of said permeabilities for reducing the difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure data". The present invention's simulation of pressure is used to calculate a correction of the permeabilities which is not done by Huh. Moreover, any estimation of pressure of Huh would not be a pressure from a well test, but instead, would be a pressure from the formation and not involve estimating corrections of said permeabilities.

Additionally, paragraph [0104] teaches the performing of simulation with simulation parameters such as permeability which are set to match experimental data. There is no estimating of corrections involved in Huh.

The Examiner, as stated above, has not described how Huh performs "reducing a difference between said production data or pressure data obtained from well test and said simulated production data or simulated pressure data." There is no counterpart in Huh or Sarda of reducing a difference between said production data or pressure data obtained from well tests and said simulated production data or simulated pressure date. Moreover, the claimed estimating corrections of said permeabilities are recited as propagated to the set of grid cells of the reservoir model by an iterative optimization process comprising minimizing a function which depends on said corrections using a technique of gradual deformation of realizations of said stochastic model. Neither Huh nor Sarda discloses propagating corrections which are estimated for reducing a difference between said production data or

pressure data obtained from well tests and simulated production data or simulated pressure data by an iterative optimization process comprising minimizing a function which depends on said corrections using a technique of gradual deformation of realizations of said stochastic model. It is submitted that none of the prior art of record discloses the foregoing function or the technique of gradual deformation.

The Examiner's reliance on paragraph [0009] of Huh as disclosing gradual deformation of realization of said stochastic model is misplaced. The description in paragraph [0009] of the physical system being modeled by dividing into smaller grid cells or blocks is a process known as discretization and is not and would not be understood by a person of ordinary skill in the art to be the gradual deformation technique as described, for example, in paragraphs [0011] – [0012] of the Substitute Specification of the present application.

In summary, neither Huh nor Sarda discloses the subject matter of steps c) and d) in which *a priori* geologic data and production data or pressure data is obtained from well tests collected in the underground reservoir.

The present invention differs significantly from the prior art of record in that the optimization process is not dependent upon the flow simulator which is used only in step c) to calculate permeabilities of the zones. In the prior art, it was necessary to make at least a close simulation within the optimization process. The reduction in the number of simulations, which is the result of the optimization step d) not requiring a simulation to be performed therein, is not suggested by either the teachings of Huh or Sarda alone or in combination.

Moreover, the Examiner in his Response to Arguments suggests that the "motivation to combine would be to use zones which allows for faster and better

simulation results because breaking things down to zone/grids allows for the simulation to have better physical representation of the reservoir as the simulations become faster and more accurate." The Examiner's analysis is based upon paragraph [0064] of Huh. However, Huh characterizes improvements resulting in more accurate and efficient prediction of adverse mobility displacements. Of course, "adverse mobility" has nothing to do with the claimed invention nor has any relationship with Sarda. The Examiner has not explained why a person of ordinary skill in the art would modify Sarda by reliance upon Huh to achieve the claimed subject matter when the claimed subject matter, Huh and Sarda are unrelated to each other.

Finally, in the Response to Arguments in Section 4.1, the Examiner concludes "one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references". As has been explained above, a person of ordinary skill in the art would not find that either Huh or Sarda discloses steps c) and d) of claim 27. The Examiner cannot assert it is improper to argue that both Sarda and Huh, which are proposed to be combined, are deficient in teaching steps c) and d). Such rebuttal is a valid and permissible basis for Applicants to argue the impropriety of the rejection of the claims on grounds of obviousness.

Moreover, as has been stated above, the Examiner's reliance upon the use of zones as a basis to combine Sarda and Huh as allowing "for faster and better simulation results because breaking things down to zones/grids allows for the simulation to have a better physical representation of the reservoir" does not explain why a person of ordinary skill in the art would consider the combination of the two references except by hindsight for any reason let alone to achieve the claimed

reservoir model involving "a permeability field constrained by *a priori* geologic data and production data or pressure data obtained from well tests collected in said underground reservoir." Clearly, Sarda pertains to a method of exploring a heterogeneous geological original reservoir by means of a transposed reservoir equivalent to the original reservoir with respect to a determined type of physical transfer function known for the original reservoir which has nothing to do with Huh's disclosure of a method of simulating one or more characteristics of a multi-component hydrocarbon-bearing formation into which a displacement fluid having at least one component is injected to displace formation hydrocarbons". It is requested that if the Examiner continues with the grounds of rejection he explain how Sarda would be modified by Huh given the total disparity between the objectives to be accomplished by Sarda's and Huh's systems including the claimed well data.

Claims 29-34 and 37-42 stand rejected on grounds of obviousness over Sarda in view of Huh further in view of United States Patent 6,549,879 (Cullick). Cullick is cited as disclosing "flow simulations carried out by means of a streamlined simulator, said zones of said underground reservoir identified by said grid cells traversed by one or more streamlines of fixed geometry and zones are defined either manually or automatically from said flow simulator". Cullick does not cure the deficiencies noted above with respect to the rejection of claim 27.

In view of the foregoing Remarks, it is submitted that each of the claims in the application is in condition for allowance. Accordingly, early allowance thereof is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 C.F.R. §1.136. Please charge any shortage in fees due in connection with the

filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (612.42904X00) and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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